Bureau of Entomology and Plant Quarantine
Agr. Res. Adm.,
U. S. D. A.
In cooperation with 13 cotton-growing States

CONFERENCE REPORT

on

COTTON INSECT RESEARCH AND CONTROL
MEMPHIS, TENNESSEE
December 7-9, 1952

(Third Memphis Report)

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This is the sixth report to summarize results of conferences of State and Federal workers concerned with cotton insect research and control in the cotton-growing States. The conferences were held at:

Stoneville, Miss., on November 17-19, 1947
Baton Rouge, La., on November 8-10, 1948
Jackson, Miss., on November 28-30, 1949
Memphis, Tenn., on December 4-6, 1950
Memphis, Tenn., on December 2-4, 1951
Memphis, Tenn., on December 7-9, 1952

Each report brings together the yearly results of research and experience in control of cotton insects. The six reports indicate much of the progress made during the last six years. In general, each supersedes the previous report but each one contains information not given in other reports. These reports are not for general distribution. However, they are available as long as the supply lasts, to entomologists and other research and extension workers, libraries, research agencies, the insecticide industry, and others interested in cotton production.

The results summarized herein should aid in the preparation of State recommendations issued for cotton insect control for 1953. Although the previous reports were not prepared for California, Arizona, New Mexico, and the western part of Texas, where all cotton is grown under irrigation, the conferees had the benefit of research and experiences of cotton entomologists in that area. Entomologists from Arizona and California participated in this conference and in the preparation of this report.

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COTTON INSECT RESEARCH AND CONTROL

Introduction

Research and extension entomologists and associated technical workers from 13 cotton-growing States (Alabama, Arizona, Arkansas, California, Georgia, Illinois, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee and Texas), the United States Department of Agriculture, and the National Cotton Council of America participated in a conference at Peabody Hotel, Memphis, Tenn., on December 7-9, 1952 to formulate a guiding statement for cotton insect control recommendations in 1953 based upon the research and experience of 1952 and previous years. Each section and sentence in this report was carefully considered and unanimously approved by all members of the conference. The conferees are listed on pages 52-55. Cultural methods and the use of insecticides for controlling cotton pests are considered in this report.

Cultural control practices cannot be too strongly emphasized. It should be recognized that control of cotton insects with insecticides is really supplemental to the adoption of good farm practices. Cultural control methods include such factors as early fall clean-up before frost where possible on farms infested with the boll weevil or pink bollworm, seed treatment, early planting, fertilization, use of proper cotton varieties, proper land use, and cultivation. Cultural measures used against cotton insects, depending upon the ones to be controlled, are influenced by climate, soil conditions, fertility, topography, and geographical location.

In addition to recommendations for the use of insecticides against cotton insects, this report presents information believed to be of value (1) to industry in planning production programs and (2) to State and Federal workers who cooperate with cotton growers in testing insecticides still in an experimental stage. It contains some suggestions as to research needs in developing more effective cotton insect control programs. A general statement of plans is included, by which extension entomologists will aid in bringing to the attention of growers and all other interested groups the 1953 cotton insect control recommendations for each State. Control recommendations are general and are not specifically fitted to local needs. It is expected that each State, in preparing recommendations for cotton insect control for 1953, will adapt to its own conditions the information given in this summary.

Policy and Ethics

The chief purpose of the Cotton Insect Conference is to enable State and Federal entomologists to make readily available to each other information that may be useful in further research and extension work in cotton insect control. This exchange of information makes mutual support possible.

While agreement on major recommendations may be expected, complete standardization is not possible. Details of recommendations must vary with requirements of the region or locality. Such variations are sometimes interpreted as disagreement among entomologists and can be a basis for confustion. To avoid this confusion, cotton growers should follow the advice of qualified entomologists in their respective States who are familiar with their local problems.

It should be recognized that procedures, equipment, and materials that may be effectively used in control of the various insect pests of cotton are now known. This knowledge adds to the stability of control recommendations. However, research is continued to find new procedures, equipment, or materials that may have advantages over those now in use. In bringing the results of new research to public attention, the impression that a panacea for all problems is being introduced tends to discredit all previous work and should be forestalled. It is desirable that results of research should not be reported to the public, or made a basis for recommendations, until they have been made available to other entomologists working in the same field.

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to the hazards to public safety and other interests involved in the use of such materials.

Unfortunately, various so-called boll weevil "remedies" have been put on the market through the years. Although some had slight value, usually most were less effective and more expensive than widely tested standard methods of insect control. Cotton growers are urged not to risk wasting money experimenting with unapproved devices, materials or mixtures. Many cotton farmers are persuaded by salesmen to spend money in purchasing mixtures and machines that have little or no value in increasing yields or improving quality of cotton.

Hazards and Precautions in the Use of Insecticides

Development of new synthetic organic insecticides provides more effective means of controlling insects, but numerous problems such as hazard to man, domestic animals, crops, fish, and beneficial wild life, have been intensified by the use of these new chemicals. Most insecticides are poisonous to animals and man; therefore, they should be used with appropriate precautions.

The factor of immediate toxicity of insecticides is of great importance to the user, livestock, beneficial insects, and plants. There is, in addition, the effect of chronic toxicity due to repeated exposures, of accumulations in soils, and of residues on treated plants and on adjacent crops caused by drift. Everyone concerned with insecticides and their use should be thoroughly familiar with these various hazards. Proper precautions should be taken when formulating, packaging, labeling, and applying these materials.

No organic phosphate or other highly toxic material should be applied by aircraft or custom sprayer in such manner that unprotected persons will be exposed to hazardous concentrations.

Packages of insecticides registered under State or Federal regulatory acts carry labels showing approved uses, unusual hazards, and antidotes if materials are highly poisonous. Users are therefore urged to read the label and follow directions explicitly.

Precautions for the User

In considering the hazards to man, it is necessary to distinguish between immediate hazards (acute toxicity) and the accumulative effects (chronic toxicity). Man can be poisoned by breathing most insecticides, by absorbing them through the skin, and by swallowing them.

Most solvents used in preparing solutions or emulsions are also poisonous. Some are inflammable. Research and experience indicate that the new chlorinated hydrocarbon insecticides are reasonably safe to man and higher animals at strengths normally applied for cotton insect control. However, in concentrated form, they may cause acute poisoning when they come in contact with the skin or are swallowed. Continued contact with or exposure to such materials may result in an injurious accumulation of the toxic ingredient in the body. Persons engaged in applying these insecticides should avoid unnecessary exposure to them. It is advisable to wear a respirator with suitable filter pads. Hands should be washed thoroughly before food is handled. After a dusting or spraying is completed, and at least once a day when handling or applying insecticides, it is advisable to bathe and change clothes.

Phosphorus compounds such as parathion, methyl parathion, EPN, schradan, and Systox are extremely poisonous materials and must be handled with great care. It is not practicable to give all precautionary measures here that should be taken when phosphorus compounds are used. Such information is available through basic manufacturers, State Experiment Stations, or the Bureau of Entomology and Plant Quarantine. All users should be thoroughly familiar with precautions and see that they are followed.

An important precaution to observe is the avoidance of breathing wettable powders, dusts, sprays, or vapors. When handling or applying parathion, use a respirator that has been passed by the U. S. Department

of Agriculture. A mimeographed circular dated August 24, 1951, was issued by the Bureau of Entomology and Plant Quarantine under the title "Respiratory Devices for Protection Against Inhalation Hazards of Dusts, Mists, and Low Vapor Concentrations of Certain Insecticides."

Loading and mixing should always be done in the open. Impervious gloves should be worn if it becomes necessary to handle the materials, but it is best to avoid unnecessary contact with insecticide sprays as well as dusts. Emulsifiable concentrates and wettable powders are especially dangerous.

It is advisable to have on hand in the field a change of clothing, soap and water, and a small supply of 1/100-gr. atropine tablets for emergency use, as recommended by competent medical authorities. Quick action is essential in case any symptoms of poisoning appear. Regular users of the organic phosphates should have their blood cholinesterase checked periodically. Persons directing control operations should assume full responsibility for enforcement of adequate precautions and should have had medical advice as to the emergency use of atropine.

No insecticides should be spilled where they might contaminate water used by man or livestock.

Excess dusts or sprays, even in small quantities, should be deeply buried.

Empty containers in which insecticides have been packaged should be burned or otherwise destroyed as soon as empty. Insecticides should always be clearly identified by labels and stored where they are inaccessible to irresponsible persons or domestic animals.

Equipment used for applying weed killers should not be used for applying insecticides because of danger of crop injury.

Residues on Plants

Spraying or dusting should be done under conditions and in a manner to avoid excessive drift to adjacent fields where animals are pastured or where food crops are being grown. Care in preventing drift is also essential because certain varieties of plants and kinds of crops may be injured by some insecticides.

In developing and using systemic insecticides the possibility of residues remaining in cotton seed products should not be overlooked.

Cotton that has received late applications of DDT and certain other persistent insecticides should not be grazed by dairy cattle.

Residues in Soils

The effect of insecticides on germination, the rate of growth, and the flavor of crops may be influenced by the type of insecticide, the formulation used, the type of soil, the kind of plant, and/or the concentrations of the residues in the soil.

Information so far indicates that there is no immediate hazard to the plant growth of any crops when amounts and concentrations recommended for the control of cotton insects are followed. Injury to several crops has been demonstrated by higher rates of application of some insecticides as soil treatments on certain soil types. Soil applications of benzene hexachloride, chlordane, toxaphene, and parathion may cause off-flavor of some crops. Cotton treated with foliage applications of benzene hexachloride often causes off-flavor in irish potatoes when this crop is planted in rotation with cotton.

Safeguarding Beneficial Forms of Life

Insecticides destroy beneficial as well as injurious insects. Some materials are highly toxic to fish and other forms of aquatic life. It is especially important to use minimum amounts where drift to ponds and streams is unavoidable. Every precaution should be taken to avoid the pollution of streams and farm ponds stocked with fish when excess spray or dust materials are being disposed of, or when equipment is being cleaned.

Preventing Honey Bee Losses

Insecticides applied to cotton may cause heavy losses to honey bees. Cotton produces tons of excellent honey that would be lost without the activity of the honey bee. Furthermore, many cotton growers are also growing legumes or other crops that require insect pollination. For the benefit of the cotton grower and agriculture in general, every effort should be made to protect pollinating insects.

The effect on honey bees should be considered whenever chemicals are applied. When evaluating the hazard to bees of a particular application, the toxicity of the insecticide to bees, the amount applied per acre, and exposure of the bees should all be taken into account. Calcium arsenate, which kills colonies outright, is the most dangerous insecticide in wide use on cotton. Organic insecticides usually kill only the field bees without destroying the colony. Experience has shown, however, that impractical use of some of these materials kill more bees than others. Parathion, EPN, malathon, BHC, lindane, and dieldrin are highly toxic to honey bees, and the bees should be moved if these materials are used. TEPP, heptachlor, chlordane, and probably aldrin may be used without hazard to honey bees if extreme precautions are employed as to timing, dosage, and applications. Toxaphene, DDT, and maybe aldrin may be used with relative safety. Methoxychlor, sulphenone, CS-708, Aramite, ovotran, sulfur, and Systox are materials of low or no hazard to bees.

Because organic insecticides kill largely by contact, applications should be made during the hours bees are not visiting the cotton.

To hold honey bee losses to a minimum, the following suggestions are made:

1. Treat only when insect infestation indicates chemical treatment is necessary.
2. Utilize nonchemical methods to their fullest to improve control and reduce necessity for insecticidal treatment.
3. Utilize careful scouting or supervised control to improve timing and to avoid unnecessary treatments.
4. Whenever possible, use the insecticides least toxic to bees.
5. Avoid drift into bee yards and adjacent crops in bloom.
6. Beekeepers should keep informed of cotton insect infestations and recommendations for their control. This knowledge will enable them to locate bee yards in the safest available places and to know where and when insecticide applications are likely to be made. They should also contact the cotton growers before the insect-control season begins, giving the location of their apiaries, and requesting the growers' cooperation.
7. Cotton growers should notify beekeepers at least 48 hours before dusting or spraying, so that any possible protection measures can be taken.
8. County agents should also be given the exact location of apiaries. They could serve as clearing houses for such notification to beekeepers and for recommendation for the materials least toxic to bees.

Honey bee losses can be reduced if better understanding and cooperation can be developed between beekeepers and cotton farmers.

Insecticide Formulations

Dusts

New organic insecticides are used as toxicants in dust mixtures with carriers such as talcs, pyrophyllite, and clays, or in mixtures with other insecticides. Too much emphasis cannot be placed upon proper formulations.

Progress has been made in the formulation of good quality dusts for use on cotton. Poor results are often due to improper application or timing. Erratic results and poor control in some instances have been attributed by research workers to inferior dusting quality of the mixtures. Use of mixtures with excellent dusting qualities is in the interest of insecticide conservation and insect control. More information on insecticidal formulations is needed to establish criteria for suitable dust mixtures of organic insecticides.

Sulfur as a diluent gives dust mixtures certain undesirable physical properties. At present, supplies of sulfur are adequate for essential insecticide uses. Where spider mites are a problem, at least 40 percent or more of a good grade of dusting sulfur or appropriate amounts of some other suitable miticide is desirable in the mixture.

Sprays

Several organic insecticides were applied widely as sprays in 1950. During the last 3 years results have proved that concentrated sprays of these insecticides will control cotton insects. Boll weevil control can be obtained with as little as 1 gallon or as much as 15 gallons of spray per acre with the toxicant remaining constant at the recommended rate. Most of the new organic insecticides are made as emulsifiable concentrates, which may be mixed with the water to give emulsions suitable for application. Slight foliage burning has been noted in some instances when the emulsifiable concentrate was poorly formulated, or when the spray was poorly distributed.

Most oil solutions of insecticides caused foliage injury. Tests of experimental oils indicate that high viscosity, high volatility and high aromatic content of the oil are the main factors causing the undesirable foliage reaction. Emulsifiers and solvents should be tested for toxicity to the cotton plant and their general suitability determined, before they are used in formulations. Phytotoxicity of the emulsions is also aggravated by high temperatures, high concentrations, and dry winds.

For stability in storage and to prevent breakdown of the formulation when metal containers are used, the containers should be lined with some material that will not react with or cause deterioration of the concentrate. It is undesirable to re-use metal containers for the packaging of emulsifiable concentrates. Used containers, especially 30- and 50-gallon drums, often have breaks in the linings. They are hard or impossible to detect and will cause a breakdown of the formulation when it comes in contact with the metal. Containers sometimes become contaminated with 2, 4-D or 2, 4, 5-T on farms. Such contamination cannot always be detected and re-use of contaminated containers might prove very hazardous to the processor and to the farmer.

Some Aspects of Insecticide Applications

Application of insecticides to cotton may be made with both ground and aerial equipment. Regardless of equipment chosen, effective insect control is obtained only when applications are thorough and are properly timed.

Improper applications may often result in development of a pest complex that can cause greater damage to the cotton crop than the one that originally required control.

Ground Application

Equipment is available for ground application of both dusts and sprays, both of which give effective insect control.

Dusts

Equal and thorough distribution of the insecticide dusts is essential for effective control. The nozzles should be adjusted to approximately 10 inches above the terminal growth of the cotton plants.

Sprays

Equal and thorough distribution of the spray is essential for effective control of cotton pests.

For treatment of seedling cotton it is suggested that one nozzle per row be used, and as the cotton increases in size the number be increased to three. In the irrigated area as many as five nozzles may be used.

The nozzle should be adjusted to approximately 10 inches from the cotton plants, and be capable of delivering 1 to 20 gallons per acre of the final mixture.

It is essential that emulsifiable concentrates be diluted immediately before use with not to exceed an equal volume of water, and the diluted emulsion then added to the required volume of water. Some type of agitation, generally the by-pass flow, is necessary during the spray operation to insure a uniform mixture.

It is recommended that the spray boom be located behind the operator as a safety measure.

Aerial Application

Aerial application of insecticides may be made either as a dust or as a spray. Results of experiments have shown that either will effectively control cotton insects when properly applied.

Certain general principles are applicable to either dusts or sprays. The width of each swath should be limited to the plane's wing span or approximately 40 feet. A method of flagging or marking should be used to secure proper distribution of the insecticide and effective control of cotton pests.

Dusts

Properly formulated insecticides of free flowability should be used to obtain even distribution. Applications should not be made when wind velocity exceeds 6 miles per hour.

Sprays

Emulsifiable concentrates should be mixed with water to desired dilution prior to loading the plane. Planes used for applications should be equipped with standard nozzles or other atomizing devices which will produce spray droplets within the range of 100 to 300 microns. This equipment should also minimize excessively large or small droplets. It should be equipped to deliver from 1 to 8 gallons of spray mixture per acre depending on local conditions.

Spray may be applied during period of wind velocity up to 15 miles per hour.

Timing of Insecticidal Applications

With presently available insecticides, successful control of cotton insects depends more on correct timing of applications than on any other factor. Consideration must be given to the overall population of beneficial and harmful insects rather than to a single pest. The stage of growth and expected yield are important.

Most insecticides kill predatory and parasitic insects as well as pest insects. Since use of insecticides often appear to induce outbreaks of bollworms, aphids, and spider mites, it is essential that insecticides be applied only where and when needed.

It is generally recommended that suitable insecticides be applied to cotton in its maximum period of fruiting and maturing of the crop, if insect infestations threaten to reduce the yield, seriously affect quality, or delay maturity. Recommendations for insecticide treatments are similar throughout the Cotton Belt, but certain details vary from State to State, and often within the State.

It is also generally recommended that early season applications be made to control cutworms and grasshoppers when they seriously threaten to reduce a stand.

Recommendations for early season applications for thrips, boll weevils, fleahoppers, and plant bugs vary greatly from State to State. Variations in early season infestations of these insects as well as many other production factors make it undesirable to attempt to standardize recommendations for early season control.

Insecticides and Miticides

Data from laboratory and field tests presented at the Conference indicated that no particular insecticide gave results outstandingly superior to those of any other recommended insecticide or mixtures of materials when they were used at the dosage, time, and frequency recommended by official entomologists for a given area. These factors are most important in the effective use of insecticides for cotton insect control.

Aldrin

Aldrin has been widely used for cotton insect control during the last 3 years. It will control the boll weevil, thrips, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, grasshoppers, and newly hatched cotton leafworms in most cases. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, the garden webworm, certain species of cutworms, the cotton aphid, or spider mites. Aldrin may increase populations of spider mites, and mixtures of aldrin and DDT may increase those of aphids. For boll weevils, aldrin should be applied at the rate of 0.25 to 0.75 pound per acre. In areas or at times when bollworms are a problem, DDT should be added in the proportion of one part of aldrin to two parts of DDT. It is effective as a dust or spray.

Aldrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it are fully aware of the hazards and will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Aramite

This material will effectively control all species of spider mites for 2 to 4 weeks or more when applied at the rate of 1 pound of technical material per acre in dusts. It is also effective as sprays when thorough coverage is obtained. It will control some species of mites at dosages as low as 1/3 pound per acre, but 2 or more applications may be required. Aramite is compatible with sulfur, but especial care should be used in formulations. Dusts should not be held in storage. Aramite has essentially no insecticidal activity.

BHC

BHC will control the boll weevil, the lygus bugs (though less effective than DDT), the rapid plant bug, thrips, the stink bugs, the garden webworm, the fall armyworm, the cotton fleahopper, the cotton aphid, and grasshoppers. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, spider mites, some species of cutworms, and the salt-marsh caterpillar. It is effective as a dust or spray. It has given erratic results against the cotton leafworm.

Except for use in early season control, BHC is usually formulated to contain DDT in the ratio of three parts of the gamma isomer to five parts of DDT in both dust and spray formulations for over-all cotton insect control. This mixture should be applied at the rate of 0.3 to 0.45 pound of the gamma isomer and 0.5 to 0.75 pound of DDT per acre.

(Example: 10 to 15 pounds of benzene hexachloride - DDT dust containing 3 percent of the gamma isomer and 5 percent of DDT). Where spider mites are a problem, the dust formulations usually contain at least 40 percent of a good grade of dusting sulfur. Another popular dust formulation contains 2 percent of the gamma isomer of BHC and 10 percent of DDT. Sprays should be formulated to contain the same amounts of each active ingredient per acre as the dusts. It is very important that the emulsifiable concentrate containing BHC be properly formulated to prevent foliage or plant injury.

BHC causes an off-flavor to Irish potatoes and possibly to other crops. It is not advisable to use materials containing BHC in controlling cotton pests on soils which will be alternated with such crops. It is highly desirable to use BHC containing a high percentage of the gamma isomer in dust or spray formulations to be used on cotton.

BHC is toxic to warm-blooded animals. It may enter the body through absorption, inhalation, or ingestion. Proper precautions in its use should therefore be observed.

See Hazards and Precautions in the Use of Insecticides, p.5, and Residues in Soils, p. 7.

Calcium Arsenate

Calcium arsenate has an excellent dusting quality and is an economical and effective insecticide for control of the boll weevil and the cotton leafworm. It is used at the rate of 7 to 10 pounds per acre for their control. Against bollworms 12 to 15 pounds per acre will give fair control, if applications are properly timed. Generally it is used undiluted against the above-mentioned insects. It often causes an increase in aphid population when used without an aphidicide. Alternate applications of calcium arsenate and formulations containing an aphidicide have given excellent results in some areas.

Lime-free calcium arsenate is compatible with organic insecticides. In some areas when it is combined with 5 percent of DDT and 1 percent of parathion (see precautions under parathion) boll weevils, bollworms, cotton aphids, and spider mites are controlled. Lime-free calcium arsenate in combination with these materials should be applied at the rate of 10 to 12 pounds per acre.

Calcium arsenate is injurious to some crops, especially legumes and oats in certain light sandy soils. It should not be used for cotton insect control in fields where rice may be planted. Drifting of the dust may injure other crops. Precautions should be taken to avoid drift that might cause bee losses. Calcium arsenate is poisonous and should be handled carefully. Livestock should be kept out of dusted fields. Care should be taken to avoid drift onto pastures, especially when applications are made by airplane.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Chlordane

Chlordane has been tested extensively and has been used on a limited commercial basis for cotton insect control during the last 5 years. It has given good results against the cotton fleahopper, the rapid plant bug, the fall armyworm, grasshoppers, the sand wireworm, darkling beetles, and thrips. Results against the boll weevil and lygus bugs have not been consistent. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, the cotton aphid, stink bugs, or spider mites.

For the insects against which chlordane is effective, from 0.5 to 1.5 pounds of the technical material per acre is required.

When used during mid- or late-season treatments for over-all cotton insect control, chlordane should always be formulated with DDT in the ratio of two parts of chlordane to one part of DDT. From 1 to 1.5 pounds of technical chlordane and from 0.5 to 0.75 pound of technical DDT per acre should be applied. It is effective as a dust or spray.

The populations of cotton aphids and spider mites may increase to damaging proportions after application of chlordane-DDT sprays and dusts. Careful inspections for these two pests should be made at weekly intervals after such application. If the numbers of either species increase, appropriate measures should be taken to control them as outlined under the respective pests.

See Hazards and Precautions in the Use of Insecticides, p. 5.

DDT

DDT will effectively control the bollworm, the pink bollworm, the fall armyworm, the tarnished plant bug, and other lygus bugs, the garden webworm, the cotton leaf perforator, the western yellow-striped armyworm, the beet armyworm, darkling ground beetles, flea beetles, the white-lined sphinx, the green stink bug, the southern green stink bug, the rapid plant bug, the cotton fleahopper, and thrips. In some instances, unsatisfactory results against thrips have been reported when the temperature exceeded 90° F. It will also control certain species of cutworms and to a lesser extent the yellow-striped armyworm. It will not control the boll weevil, the cotton leafworm, spider mites, the cotton aphid, and grasshoppers.

As a dust on cotton, DDT is ordinarily used at concentrations of 5 to 10 percent, either alone or in combination with other insecticides and miticides, at 10 to 30 pounds per acre. At least 15 pounds per acre of 10-percent DDT should be applied for pink bollworm control.

Sprays and dusts containing DDT are about equal in effectiveness against cotton pests. Thorough coverage of the plant and proper timing of applications are more important than the type of formulation used.

Aphid and mite populations may increase until they cause severe injury where DDT is used, unless an aphidicide or a miticide is included in the formulation.

DDT is toxic to certain plants such as cucurbits. Its toxicity persists and accumulates in the soil. Therefore, it should be used only in the minimum amounts recommended for cotton insect control, especially on light sandy soils. Contamination of adjacent crops from drift should be avoided.

DDT is highly toxic to fish and amphibians, and precautions should be taken to avoid the possibility of polluting streams.

Acute toxicity of DDT to man and animals is rather low compared with inorganic insecticides now used on cotton. However, when DDT is repeatedly ingested or brought into contact with the skin, it may be absorbed and stored in the fatty tissues. Injury to the liver may also result. Unnecessary exposure of operators should be avoided.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Dieldrin

Dieldrin will effectively control the boll weevil, thrips, stink bugs, the cotton fleahopper, lygus bugs, the rapid plant bug, the fall armyworm, grasshoppers, the variegated cutworm, the pale-sided cutworm, the granulate cutworm, the yellow-striped armyworm, and the garden webworm. It is not effective at low dosages for bollworm control and DDT should be added when control of this insect is necessary. Dieldrin may increase the numbers of spider mites and aphids. Against boll weevils dieldrin should be applied at the rate of 0.15 to 0.5 pound per acre. It will kill newly hatched cotton leafworms at dosages effective against the boll weevil. It is effective either as a dust or spray.

Dieldrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Heptachlor

Heptachlor was used experimentally for cotton insect control in many locations throughout the Cotton Belt in 1951 and 1952 and was recommended for this control in several States in 1952. It is effective against the boll weevil when applied at the rate per acre of 0.25 to 0.75 pound, against thrips and cotton fleahoppers at 0.125 pound, against cutworms at 1 pound, against garden webworms at 0.5 pound, and against grasshoppers at 0.25 to 0.5 pound. Heptachlor will not control the bollworm, the yellow-stripped armyworm, the pink bollworm, the cotton leafworm, the cotton aphid, or spider mites. Heptachlor and heptachlor-DDT mixtures may increase spider mite and aphid populations.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Lindane

Lindane, the essentially pure gamma isomer of BHC, may be substituted on an equivalent weight basis for the gamma isomer of BHC in formulations of insecticides used on cotton insects.

Lindane is toxic to warm-blooded animals. It may enter the body through absorption, inhalation, or ingestion. Proper precautions should therefore be observed in its use.

Lindane dusted or slurried onto planting seed at the rate of 2 ounces per 100 pounds will control wireworms, seed corn maggots, and false wireworms.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Methoxychlor

Dusts containing 10 percent of methoxychlor controlled the cotton leafworm, but lower concentrations gave poor control.

Methoxychlor gave slightly better control of the pink bollworm than DDT, but a heavy build-up of aphids usually followed its use and it failed to control bollworms. Therefore, it is not being generally used for pink bollworm control.

Methoxychlor is less effective than the insecticides now recommended for the control of the boll weevil, the bollworm, the cotton aphid, the garden webworm, spider mites, and stink bugs. It is less toxic than DDT to warm-blooded animals and it is less likely to be stored in the fat or excreted in the milk.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Nicotine

Two percent of nicotine alternated with applications of calcium arsenate alone will usually prevent a cotton aphid build-up, if properly applied. The period between nicotine applications should not exceed 8 to 10 days.

Either 2 or 3 percent of nicotine in a suitable carrier can be used to knock out heavy aphid infestations. At least 0.2 pound per acre of free-nicotine equivalent should be applied. The source may be either nicotine sulfate or a fixed nicotine in dust form.

Nicotine dusts to knock out heavy aphid infestations should be applied when the air is calm and preferably when there is no dew on the plants. Complete coverage is essential.

Nicotine is highly toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Parathion

Parathion will control the cotton aphid, spider mites, the garden webworm, and the cotton leafworm when applied at the rate of 0.125 to 0.25 pound of the technical material per acre. It may be applied as a dust or spray. It may be used as a 1-percent dust alone or in combination with other insecticides. It gives very little control of the boll weevil, the fall armyworm, the variegated cutworm, the bollworm, and the pink bollworm. Bollworm infestations sometimes increase after applications of parathion.

Parathion is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p.5.

Rotenone

One percent of rotenone in calcium arsenate at each application made against the boll weevil has given satisfactory control of the cotton aphid.

Sulfur

Sulfur has been widely used in dust mixtures on cotton for control of certain species of spider mites and the cotton fleahopper. It sometimes has a repressive effect upon aphid populations in some areas. Where spider mites are a problem, at least 40 percent of sulfur should be included in all dust mixtures to prevent the development of damaging infestations of the sulfur-susceptible species and as a depressant of the others. Sulfur is most effective when finely ground and when applied at temperatures above 90° F.

Systox

Systox is effective against cotton aphids and all species of spider mites for 2 to 8 weeks at dosages from 0.2 to 0.5 pound per acre. For soil treatment 2 to 4 pounds per acre are required, and for seed treatment 0.25 to 0.50 pound. In addition to systemic activity, Systox also has shown marked activity as a contact insecticide against spider mites and aphids. It does not control the boll weevil, the bollworm, the cotton leafworm, thrips, the pink bollworm, or grasshoppers at the dosages that are effective against mites and aphids.

Systox is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

TEPP

TEPP at the rate of 0.5 to 1.0 pint of the 40-percent concentrate, or its equivalent, will control cotton aphids and some species of spider mites when used on dry plants at proper intervals. Several applications may be required for spider mite control.

This chemical deteriorates rapidly when exposed to moisture or moist air and is incompatible with alkaline materials. It should be applied immediately after being mixed with water. Residual toxicity of the chemical is very short.

TEPP is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Toxaphene

Toxaphene will control the boll weevil, the fall armyworm, the garden webworm, the cabbage looper, the tarnished plant bug, the rapid plant bug, the cotton leafworm, cutworms, and grasshoppers, when applied at the rate of 2 to 3 pounds of the technical material per acre. It is less effective against the bollworm and yellow-striped armyworm. It will control the cotton fleahopper and thrips when applied at the rate of 0.75 to 1 pound of the technical material per acre. When properly applied dusts and sprays are about equally effective in most areas. It is effective against the salt-marsh caterpillar at 4 to 5 pounds per acre.

Bollworm control was improved where DDT was incorporated in the toxaphene spray mixture at the rate of 0.25 to 1 pound per acre. Toxaphene alone will not give adequate control of the pink bollworm.

Suppression of the cotton aphid was not satisfactory where toxaphene was used throughout the season. It will not control heavy aphid infestations, nor will it control spider mites, and its use may result in their increase. Therefore, in some areas it is recommended that dusts contain at least 40 percent of sulfur, or an appropriate amount of some suitable miticide.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Insecticides and Miticides That Show Promise for Commercial Use and Are Recommended for Large-Scale Field Trials During 1953

Chlorthion (Compound 22/190)--A phosphoric acid ester related to parathion containing chlorine.

This phosphorus compound is reported to be nontoxic to warm-blooded animals. It was tested against the boll weevil, the bollworm, the cotton aphid, and spider mites in laboratory and field cages and in field plots during 1952. It appears promising for control of the boll weevil at dosages ranging from 0.25 to 0.75 pound of the technical material per acre. At this dosage, aphid control would be highly satisfactory and the build-up of damaging spider mite infestations would likely be prevented. It is not effective against the bollworm at these dosages and should be formulated with DDT when used for over-all cotton insect control.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Endrin

Endrin (Compound 269) was used as a spray in large-scale field tests for cotton insect control in many locations throughout the Cotton Belt in 1952. It is effective against the boll weevil and the bollworm when applied at the rate of 0.2 to 0.5 pound per acre; against thrips, the cotton fleahopper, and lygus bugs at 0.1 pound per acre; and against the cotton leafworm at 0.2 pound per acre. Endrin did not control spider mites, aphids, or the pink bollworm.

Endrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it are fully aware of the hazards involved and will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 5.

EPN

EPN was used experimentally for cotton insect control in many locations throughout the Cotton Belt in 1952. It is effective against the boll weevil when applied at a rate of 0.5 to 0.75 pound per acre; against the yellow-striped armyworm at 0.3 pound per acre; and against thrips, the cotton fleahopper, the cotton leafworm, and some species of spider mites at 0.25 pound per acre. Aphids and bollworms may build up to damaging numbers after its use, but spider mites do not.

A mixture of EPN and DDT was more effective against the pink bollworm than DDT alone. EPN at the rate of 1 pound per acre showed promise for pink bollworm control.

EPN is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Isodrin (Compound 711)

In South Carolina isodrin gave effective control of the boll weevil at 0.2 pound per acre, both as a dust and a spray. At this dosage it ranked first in six out of seven field-plot experiments against this insect.

In Texas isodrin gave good initial kill of thrips and the cotton fleahopper when applied at 0.1 pound per acre and against the cotton leafworm at 0.3 pound in limited field tests.

When mixed with DDT it usually caused an increase in aphids and spider mites, although less than most of the insecticide formulations recommended for boll weevil and bollworm control. When used alone it usually did not cause an increase in these pests.

Isodrin was not effective against the bollworm, the fall armyworm, the yellow-striped armyworm, aphids, and spider mites.

Isodrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it are fully aware of the hazards involved and will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Malathon

This compound appears promising for the control of spider mites and the cotton aphid at a dosage of 0.25 to 0.5 pound of the technical material per acre.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Methyl Parathion (Methyl ester of parathion)

This compound was widely tested during 1952 and continues to appear promising against the boll weevil at dosages between 0.25 and 0.5 pound of the technical material per acre although at the lower strength, results have not been consistent. Within this range, it would be highly effective against the cotton aphid, spider mites, and the cotton leafworm. It is not effective against the bollworm.

Methyl parathion is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Ovotran

This material will effectively control all species of spider mites when applied at the rate of 2 to 3 pounds of technical material per acre. Thorough treatment and contact of the mites is essential for good control. Its action is somewhat slower than Aramite. Where immediate "knock down" of mites is essential, the addition of parathion or TEPP to ovotran should be considered.

Schradan

Schradan was translocated by cotton plants in laboratory tests when it was applied to soils in which the plants were growing. A single soil application of 4 to 8 pounds of the compound per acre caused the plants to remain toxic to cotton aphids and spider mites for several months. In laboratory and field tests spray application to foliage of 0.5 to 1 pound per acre gave aphid and mite protection for 2 to 4 weeks. Cotton seedlings grown from seed treated with 1 pound of schradan per 100 pounds of seed were toxic to aphids and mites for 6 weeks. Schradan was ineffective against the boll weevil, the bollworm, the pink bollworm, the cotton leafworm, the cotton fleahopper, thrips, and a number of other cotton insects.

Schradan is a dangerous poison. It is much more toxic to warm-blooded animals than most poisons used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p.5.

Strobane (B. F. Goodrich Insecticide 3960-X14)

This material, which is a mixture of chlorinated terpene isomers having approximately 65 percent of chlorine, was considerably less effective than toxaphene against the boll weevil and the cotton leafworm in field-cage tests. The amounts of active ingredient per acre required to cause mortalities of 50 percent against the boll weevil were 1.05 and 2.05 pounds, respectively, for toxaphene and Strobane; against the cotton leafworm, these amounts were 0.84 and 1.04 pounds, respectively.

Strobane is about as toxic to warm-blooded animals as toxaphene and should be handled with care.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Suggested Methods for Making Uniform Surveys to Determine the Abundance of Cotton Pests

Boll Weevil

Survey records are made in a number of States to determine the winter survival of the boll weevil. Counts are made in the fall soon after weevils enter hibernation and again in the spring before they emerge from winter quarters. A standard sample is 2 square yards of surface woods trash taken from the edge of a field where cotton was grown during the season. At least five samples are taken from a field.

In most States boll weevil population counts are made on seedling cotton to determine the number of weevils entering cotton fields from hibernation quarters. The number per acre is figured by examining the seedling plants on 50 feet of row in each of five representative locations in the field. Additional counts are desirable in large fields.

Examination for boll weevils are made weekly after the plants are squaring freely or have produced as many as three squares per plant. One hundred squares are examined while walking diagonally across the center of the field. The squares should be one-third grown or larger, and an equal number should be picked from the top, middle, and lower branches of the plants. Squares from the ground or dried-up squares that are "hanging" on the plant should not be picked.

An alternative method is to count about 25 squares in each of several locations distributed over the field. The percentage of infestation is determined by counting all squares that have egg or feeding punctures. However, the number of sample counts will depend upon the size of the field and the surrounding environment. Accurate infestation records in large fields will require additional counts in different parts of the field.

Bollworm

Examinations for bollworm eggs on cotton are started when most of the corn silks begin to dry, or at the time bollworms usually appear, and are repeated every 5 days thereafter until the crop has matured.

Terminals (about 3 or 4 inches of the top of the cotton plant) of 100 main stems are examined for eggs and worms. When first deposited, the eggs are white and about the size of mustard seed. As hatching time nears, they change to a dirty white. These eggs usually will be found scattered on the terminal portions of the plant.

If eggs are found on the terminals and 4 or 5 yound worms in small squares or on tender top leaves, infestation is high enough to start treatment. To obtain effective control, no time should be lost in applying poisons. Apply poison at 5-day intervals as long as necessary.

To determine the injury caused by this pest, the percentage of injured squares and bolls should be recorded at 5-day intervals. A sufficient number of squares and bolls should be examined to obtain adequate samples of a given field.

Cotton Aphid

The aphid infestation is classified according to the number of aphids estimated per leaf as follows:

Class 1 - 0
Class 2 - 1 to 10 per leaf
Class 3 - 11 to 25 per leaf
Class 4 - 26 or more per leaf

Beginning at the margin of the field and while walking diagonally across it, 100 leaves should be examined successively from near the bottom, near the middle, and near the top of the plants.

Cotton Fleahopper

Weekly inspections should be made as soon as the cotton is old enough to produce squares and should be continued until the crop is set and begins to mature. The main stem terminal "bud" of 100 cotton plants per field, including about 3 or 4 inches of the terminal bud or top of the cotton plant should be examined. Both adults and nymphs should be counted. The number per 100 terminals being recorded as the infestation for the field.

The examinations should be made at several representative points diagonally across a field, 33 terminal buds being inspected approximately 50 feet from each of the 2 corners and 34 terminal buds at the center of the field.

Cotton Leafworm

Two types of damage to the leaves are produced by the feeding of the cotton leafworm--(1) Semitransparent spots where newly hatched larvae are feeding on the lower surface of the leaf; and (2) ragging where larger larvae are eating through the entire leaf.

Numerous semitransparent spots, with small larvae present, indicate that a heavy infestation is developing. Three levels of infestation, based on the degree of ragging and the number of larvae, are suggested:

Class 1 - Few leaves ragged and few larvae observed.
Class 2 - 2 to 3 leaves per plant 1/3 to 1/2 destroyed by ragging, and 2 to 3 larvae per plant.
Class 3 - Extensive damage to most leaves with 6 to 8 or more larvae per plant.

Pink Bollworm

Bloom Infestation: After cotton has been blooming at least 5 days, pink bollworm infestation counts may be made on the basis either of the percentage of blooms infested or the number of worms per acre. To determine the percentage of blooms infested, record the number of infested and noninfested blooms of a representative number of blooms distributed over the field. To determine the number of worms per acre, step off 100 steps or 300 feet at each of five locations in the field or a total of 1,500 feet of row length and count the number of infested blooms on this area. The number of infested blooms multiplied by 10 will give the approximate worm population per acre.

Boll Infestation: White walking diagonally across the field, collect at random 100 green bolls that are hard or firm when pressed. Examine each boll as follows: Remove the bracts and calyx by cutting off a thin slice of the base of the boll; cut each section of the boll midway between the sutures so that each lock can be removed intact; examine the inside of the carpel for the characteristic tunnels or mines made by the young larvae. The number of bolls found infested represents the percentage of infestation.

Spider Mites

Classify the infestation by estimating the number of adult females per leaf as follows:

Class O - No infestation
Class 1 - 1 to 10 per leaf
Class 2 - 11 to 25 per leaf
Class 3 - 26 or more per leaf

Beginning at the margin of the field and walking diagonally across it, examine 100 leaves or more taken successively from near the bottom, near the middle, and near the top of the plants.

Cultural Practices That Aid in the Control of Cotton Insects

Certain cultural practices reduce cotton losses from insect pests. They often reduce, and may eliminate, the need for insecticides, and therefore should be encouraged. Several of these practices can be used by every cotton grower, whereas others are applicable only to certain areas and conditions. Besides following these practices, growers should continue to make careful observations for insects and apply insecticides when needed.

Planting

Reasonably early planting of all cotton during a short period within an area enables the crop to produce maximum growth and fruit before insects multiply and spread from field to field. Early planting also makes earlier stalk destruction possible.

Varieties

Varieties of cotton that bear prolifically, fruit early, and mature quickly may set a crop before the boll weevil and other insects become numerous. This is especially true when other cultural control practices are followed.

Soil Improvement

Cotton growing rapidly in rich soil can stand more insect injury without material reduction of yield than cotton growing in poor soil. Fertilization, rotation of crops, and plowing under of green manure generally tend to offset insect losses for this reason.

Other Host Crops of Cotton Pests

Cottonfields should be located as far as is practicable from other host plants of cotton insects. Thrips breed in onions, potatoes, carrots, and some other crops. They later move in great numbers into adjacent or interplanted cotton. Garden webworms, variegated cutworms, and lygus bugs may migrate to cotton from alfalfa. The cotton fleahopper migrates to cotton from croton and other weeds.

Hibernation Areas

Boll weevils hibernate in well-drained, protected areas in and near cottonfields during the winter. Spider mites hibernate in low-growing

plants in or near fields. Clean cultivation reduces weevil hibernation quarters. Small patches of weeds near fields, along turnrows and fences, or around stumps and scattered weeds in cultivated fields or pastures can be destroyed at small cost. Such practices are more effective where the cotton acreages are in sizeable blocks than in small patches. General burning of ground cover in woods is not recommended.

Early Stalk Destruction

The destruction or killing of cotton plants as early as possible before the first killing frost, either by mechanical or chemical methods, forces boll weevils into starvation before they go into winter quarters. Early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem in the Lower Rio Grande Valley and other parts of Texas. The importance of this practice is also recognized in pink bollworm control in most areas. Plowing under the crop residue as deeply as possible after the stalks are cut also will reduce the pink bollworm survival. Modern mechanically-operated stalk cutters and shredders facilítate early stalk destruction and complete coverage of crop residues.

Legumes in Relation to Cotton Insect Control

Soil-building and soil-conserving leguminous crops are generally fundamental in a cotton-growing program. It is recognized that a number of insects attack legumes and then transfer to cotton, thereby increasing the cotton insect problems. This situation may have a tendency to discourage the use of legumes, but this should not be so. Entomologists should give serious consideration to controlling insects on both legumes and cotton.

Chemical Defoliation as an Aid to Insect Control

Chemical defoliation of cotton aids in the control of many cotton insects. It checks the growth of the plants and accelerates the opening of the bolls, thereby reducing the damage and the late seasonal build-up in the population of the pink bollworm and the boll weevil to infest next year's crop. It also prevents damage to open cotton by heavy infestations of aphids and the cotton leafworm.

Early defoliation permits quicker harvesting and better use of mechanical pickers. It also permits earlier destruction of the stalks, an important aid in the control of the pink bollworm and the boll weevil. However, if losses in yield and quality are to be avoided, the youngest bolls to make cotton should not be less than 30 days old at the time of defoliation.

Detailed guides for use of different defoliants, and rates and methods of application, will be found in the Annual Report of Progress from the Cotton Defoliation Conference, issued by the National Cotton Council of America, Memphis, Tenn. This report contains information concerning the influence of plant activity, stage of maturity, and effects of environment on efficiency of the process. The report gives details relative to the various needs and benefits. It explains how loss in yield and quality of products may be caused by improper timing of the applications.

These guides to the use of the defoliation process are based on broad ecological areas, rather than on State boundaries. An individual should consult local agricultural specialists if he has any doubt concerning proper methods, time of application, or actual need for the process.

Machines of no Value in Increasing Yields of Cotton

Bug-catching Machines

Bug-catching machines are not recommended as a means of controlling cotton insects.

Electronic Devices

No evidence has yet been discovered by any recognized research agency which would support claims of effectiveness of so-called electronic devices for the control of insects in the field. Such devices are not recommended.

Production Mechanization in Cotton Insect Control

In the mechanization of cotton production more and more cotton is being cultivated with a tractor, thereby making it possible to apply certain insecticides with the cultivating operation. The tractors have also made it possible for cotton growers to use shredders, strippers, mechanical harvesters, and larger and better plows, all equipment that helps directly and indirectly in the control of the pink bollworm and the boll weevil.

In some soil types and at high temperature the dust mulch resulting from cultivation may aid in destroying boll weevil grubs in the fallen squares that are exposed to direct sun.

The flaming operation for weed control is of questionable value in insect control.

Mechanical cotton pickers appear to have no direct effect on insect control, except that they require chemical defoliation, which has definite value in insect control. Cotton strippers have an influence on pink bollworm control, for the infested bolls are collected and

and transported to gins so that any pink bollworms in the seed or refuse may be more easily destroyed.

Cotton stalk shredders not only destroy certain insects, particularly pink bollworms, but are of special value in enabling the cotton growers over wide areas to have the cotton stalks destroyed before frost, thus stopping the development of late generations of the boll weevil and the pink bollworm. Shredders also destroy the food and hiding places of these insects.

Fumigation of mechanical cotton pickers and strippers moving from pink bollworm infested areas to noninfested areas is required by quarantine requlations.

Cotton Insects

Bean Thrips

The bean thrips, Hercothrips fasciatus (Perg.), is a common midseason pest of cotton in parts of California. DDT at 1 pound or toxaphene at 2 to 3 pounds per acre gives satisfactory control when applied as either sprays or dusts. See Thrips on Seedling Cotton on p. 40.

Beet Armyworm

The beet armyworm Laphygma exigus (Hbn.), commonly attacks seedling cotton plants and occasionally older plants in the western part of the Cotton Belt. DDT at the rate of 1 to 1.5 pounds and toxaphene at the rate of 2 to 4 pounds are effective controls for this insect.

Boll Weevil

Variations in the effectiveness of insecticides approved for control of the boll weevil, Anthonomus grandis Boh., have been observed in local areas across the Cotton Belt. The choice of insecticides will be determined by their effectiveness in the particular area where the insect is to be controlled. Insecticides that have effectively controlled the boll weevil in one or more areas are as follows:

Insecticide	Type of Application	Pounds of Active Ingredient per Acre
Aldrin	Spray or dust	0.25 to 0.75
BHC (gamma isomer)	Spray or dust	0.3 to 0.45
Calcium arsenate	Dust	7 to 10
Chlordane	Spray or dust	1 to 1.5
Dieldrin	Spray or dust	0.15 to 0.5
Heptachlor	Spray or dust	0.25 to 0.75
Toxaphene	Spray or dust	2 to 3

However, when these insecticides are used for late-season boll weevil control, other insect problems have to be considered. Infestations of the cotton aphid, the bollworm, and/or spider mites may develop when some of these insecticides are used alone. The bollworm and the tobacco budworm are the principal insects to be reckoned with in this category, and because of the danger of their rapid build-up, DDT should always be formulated with aldrin, BHC, chlordane, dieldrin, and heptachlor. (For rates see under the respective insecticides.) Calcium arsenate and toxaphene will sometimes control bollworms without the addition of DDT, but when they are used alone during the late season, careful check at 3- to 5-day intervals should be made to determine the presence of these insects. If their numbers are found to be increasing, DDT should be included in subsequent applications or separate applications of DDT alone should be made.

Aphids may build up rapidly after the use of calcium arsenate or DDT, or aldrin, chlordane, dieldrin, heptachlor, and toxaphene when formulated with DDT. Spider mites may build up rapidly after the use of aldrin, BHC, chlordane, dieldrin, heptachlor, or toxaphene either when used alone or with DDT. Careful checks at 5- to 7-day intervals should be made to determine the presence of these pests, and if found to be increasing, appropriate control measures (see section under "Aphids" and "Spider Mites") should be started at once.

Insecticides should be applied for boll weevil control when definite need is indicated. Except where early season control measures are practiced, insecticides should be applied at intervals of 4 to 5 days until the infestation is brought under control. Fields should be inspected weekly thereafter and applications made when necessary.

Bollworms

The bollworm, Heliothis armigera (Hbn.), and the tobacco budworm, H. virescens (F.), are the common bollworms attacking cotton. The tobacco budworm is the predominant species in many collections of bollworms from cotton, particularly in the eastern part of the Cotton Belt. Several other species of lepidopterous larvae that sometimes also cause boll injury are discussed elsewhere.

It is sometimes a difficult task to control bollworms and many erratic results have been reported.

Effective bollworm control depends on the thorough and timely use of properly formulated insecticides. Frequent field inspections to determine the presence of eggs and young larvae during the main fruiting period of cotton in any given field are essential. It is too late for effective control after the larvae have already entered the squares and bolls.

The most effective insecticide for bollworm control is DDT. For heavy bollworm infestations it should be applied at the rate of 1 to 1.5 pounds of the technical material per acre in a 10 percent dust or concentrated spray. DDT may be used in mixtures with other insecticides where other insects as well as bollworms require control. It is compatible with lime-free calcium arsenate, but not with regular calcium arsenate. Bollworms usually are controlled where 0.5 pound or more of DDT per acre is applied with BHC, aldrin, chlordane, dieldrin, or heptachlor in the regular schedule for boll weevil control.

Toxaphene, at the rate of 2 to 4 pounds of the technical material per acre, is the next most effective insecticide against bollworms. This may be applied as a 20 percent dust or as a spray. The addition of DDT to toxaphene dust or spray greatly improves the effectiveness of this insecticide for bollworm control.

Calcium arsenate and cryolite dusts are less effective.

In areas where spider mites are a problem, dust mixtures containing organic insecticides used for the control of bollworms should include 40 percent of sulfur or an appropriate amount of some other suitable miticide.

Cotton Aphid

Heavy infestations of the cotton aphid, Aphis gossypii Glov., often occur on cotton after the use of certain insecticides. Infestations also may be severe on seedling cotton where no insecticides have been applied.

The following treatments, when used in the boll weevil area, will usually prevent an aphid build-up:

1. A dust mixture containing 3 percent of the gamma isomer of BHC and 5 percent of DDT in every application at the rate of 10 to 12 pounds per acre.
2. A dust mixture containing 3 percent of the gamma isomer of BHC and 5 percent of DDT at the rate of 10 to 12 pounds per acre in alternate applications with calcium arsenate.
3. Nicotine 2 percent in regular calcium arsenate dust at the rate of 10 to 12 pounds per acre alternated with calcium arsenate alone.
4. Parathion 1 percent in lime-free calcium arsenate dust, or 1 percent in dust or 0.1 pound per acre in spray added to aldrin plus DDT, dieldrin plus DDT, heptachlor plus DDT, or toxaphene plus DDT will effectively control the cotton aphid when any of these mixtures are used at the recommended rate for boll weevil control. However, parathion should be used only by those who are qualified to handle such a dangerous material.

5. Toxaphene at the rate of 2 to 3 pounds of the technical material per acre in every application (where toxaphene is not formulated with DDT), either as a dust or spray.

When heavy infestations of the cotton aphid occur and the need for rapid kill is indicated, the following treatments are effective. Heavy reinfestations are likely to recur in some areas in about 2 weeks after the use of BHC, parathion, and TEPP.

1. BHC applied wither as a dust or spray to give 0.3 to 0.45 pound of the gamma isomer or an equivalent amount of lindane per acre.
2. Parathion applied either as a dust or spray at a rate of 0.1 to 0.25 pound per acre of technical material.
3. Nicotine 3 percent in hydrated lime dust applied at the rate of 10 to 15 pounds per acre.
4. TEPP 40 percent applied in a spray at the rate of 0.5 pint, or its equivalent, per acre. The effectiveness of this material is of short duration.
5. Systox applied as a spray at a rate of 0.25 to 0.5 pound per acre.

Cotton Fleahopper

The cotton fleahopper, Psallus seriatus (Reut.), can be controlled with the following dusts applied at the rate of 10 pounds per acre: DDT 5 percent, toxaphene 10 percent, dieldrin 1.5 percent, aldrin 2.5 percent, heptachlor 2.5 percent, and BHC (gamma isomer 1 percent), and chlordane 2 percent. When spider mites are likely to be a problem, 40 percent or more of sulfur or an appropriate amount of some other suitable miticide should be added to organic insecticide formulations.

The following materials applied as low-gallonage sprays at the rates indicated per acre will give good control of the cotton fleahopper; 0.5 pound of DDT, 1 pound of toxaphene, 0.5 pound of toxaphene plus 0.25 pound of DDT, 0.1 pound of dieldrin, 0.2 pound of aldrin, 0.2 pound of heptachlor, or 0.5 pint of 40 percent TEPP.

Cotton Leaf Perforator

The cotton leaf perforator, Bacculatrix thurberiella Busck, is at times a serious defoliator of cotton in certain areas of southern Californis and Arizona. It is easily controlled with DDT at the rate of 1 pound per acre.

Cotton Leafworm

The cotton leafworm, Alabama argillacea (Hbn.), has been controlled successfully for many years with calcium arsenate, paris green or lead arsenate. Effective control is obtained with 20-percent toxaphene dust applied at the rate of 10 pounds per acre or at 1.5 pounds per acre applied as a spray. Toxaphene-DDT mixture applied as a spray at the rate of 1 pound of toxaphene and 0.5 pound of DDT per acre, or parathion applied at the rate of 0.125 pound per acre as a dust or spray is also effective. When following a regular program for control of other cotton insects, dust formulations containing 3 percent of the gamma isomer or 3 percent of the gamma isomer plus 5 percent of DDT applied at 10 pounds per acre and BHC-DDT spray applied at the rate of 0.3 pound of the gamma isomer and 0.5 pound of DDT per acre have given effective control.

Crickets

Several species of crickets sometimes attack cotton. The field cricket, Acheta assimilis F., occasionally feeds on cotton bolls and seedling plants in the Imperial Valley of California. They may be controlled with dusts containing 10 percent of DDT or 5 percent of chlordane applied at the rate of 20 to 25 pounds per acre. The dust containing 2 percent of BHC plus 5 percent of DDT plus 40 percent of sulfur is also effective.

Cutworms

A number of species of cutworms, including the following, may develop in weeds or crops, especially legumes:

Black cutworm, Agrotis ypsilon (Rott.)
Pale-sided cutworm, Agrotis malefida Guen.
Variegated cutworm, Peridroma margaritosa (Haw.)
Granulate cutworm, Feltia subterranea (F.)
Army cutworm, Chorizagrotis auxiliaris (Grote)

Cutworms migrate to adjacent cotton or attack cotton planted on land previously in weeds or legumes.

Recommended control measures include thorough seed-bed preparation, elimination of weed host plants, and the use of insecticides. In western areas, irrigation of the fields forces the subterranean forms to the surface, where they may be treated with insecticides or destroyed by natural factors. If the need for insecticides to save the stand is to be avoided, at least 3 weeks should elapse between the time an infested area is plowed under and the subsequent cotton crop is seeded.

Toxaphene and toxaphene-DDT sprays applied at a rate of 2 to 3 pounds per acre, DDT and heptachlor sprays at 1 to 15 pounds per acre, and dieldrin at the rate of 3/8 to 1/2 pound per acre are effective. Twenty percent toxaphene or 10 percent DDT dusts applied at rates of 10 to 15 pounds per acre will give satisfactory control. Poison baits containing paris green, cryolite, sodium fluosilicate, toxaphene, or DDT have been satisfactory. A bait containing 80 percent of bran, 11 percent of oil, and 8 to 9 percent of a 25 percent emulsifiable DDT applied at the rate of 15 to 20 pounds per acre has given effective control.

Fall Armyworm

The fall armyworm, Laphygma frugiperda (J.E. Smith), occasionally occurs in sufficient numbers to damage cotton. The following dusts have given good control: Toxaphene 20 percent at the rate of 10 to 15 pounds per acre, sufficient BHC to give 3 percent of the gamma isomer plus 5 percent of DDT at the rate of 10 to 15 pounds per acre, chlordane 10 percent at the rate of 15 to 20 pounds per acre, or DDT 10 percent at the rate of 10 to 15 pounds per acre. A 5-percent DDT dust will control small worms. Toxaphene at the rate of 2 to 2.5 pounds per acre or DDT applied at the rate of 0.5 to 1 pound of the technical material per acre in sprays have given good control. Other insecticides that have been effective when applied as sprays are dieldrin 0.15 to 0.30 pound of technical material per acre, BHC containing 0.40 to 0.60 pound of gamma isomer per acre, and aldrin 0.25 to 0.50 pound of technical material per acre. The results obtained from the above materials have varied in different States, therefore, local recommendations are advisable. (Also see Bollworms, p. 30.)

False Wireworms

Larvae of darkling ground beetles belonging to the genera Blapstinus and Ulus occasionally affect the stand of young cotton in the western areas. They may be controlled by slurrying 2 ounces of lindane onto each 100 pounds of planting seed. On young cotton plants they may be controlled with 5-percent chlordane dust applied at the rate of 20 pounds per acre, or with toxaphene, DDT, or a toxaphene-DDT 2 to 1 mixture applied as sprays at the rate of 1 to 2 pounds of technical material per acre.

Garden Webworm

The garden webworm, Loxostego similalis (Guen.), may be controlled on cotton by dusts containing 5 percent of DDT plus sufficient BHC to give 3 percent of the gamma isomer, 20 percent of toxaphene, 1 percent of parathion, or 10 percent of DDT. Good control of this insect may be obtained with toxaphene. toxaphene plus DDT, DDT, heptachlor, and

dieldrin sprays. DDT has given better control in sprays than in dusts and is generally less effective than the other listed materials. Calcium arsenate may also be used to control the garden webworm, but heavy dosages are required and control is generally less satisfactory than with the new organic insecticides.

Grasshoppers

Several species of grasshoppers attack cotton, particularly the differential grasshopper, Melanoplus differentialis (Thos.) and the American grasshopper, Schistocerca americana (Drury). The adults of S. americana hibernate and deposit their eggs in the fields, but most other species overwinter in eggs in untilled soil, in fence rows, sod waterways, around stumps, and in similar locations. The overwintering species can best be controlled by early treatment of hatching beds before the grasshoppers migrate into the fields. Sprays or dusts containing aldrin, chlordane, heptachlor, dieldrin, toxaphene, or BHC are rapidly replacing poison baits for grasshopper control in many areas. This is particularly true where grasshoppers must be controlled on lush or dense vegetation.

BHC sprays and dusts usually kill the grasshoppers in a few hours, but results have been erratic and residual effectiveness is limited to 1 or 2 days. Aldrin, chlordane, dieldrin, and toxaphene are very effective but slower in their action. However, they remain residually effective for 5 to 14 days, depending on prevailing environmental conditions.

Dosages suggested to control grasshoppers fall within the following ranges:.

	Pounds of technical material per acre
Aldrin	0.1 to 0.25
BHC, gamma isomer	0.3 to 0.5
Chlordane	0.5 to 1.5
Dieldrin	0.07 to 0.125
Toxaphene	1.0 to 2.5
Heptachlor	0.25 to 0.5

The lowest dosages suggested are effective against newly hatched to half-grown grasshoppers. The dosage should be increased as the grasshoppers mature or when the materials are applied on partly defoliated plants or on plants unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control where treatment of extensive areas is required, particularly in sparse vegetation.

Lygus Bugs and Other Mirids

The tarnished plant bug, Lygus lineolaris (P. de B.); the other lygus bugs, L. hesperus Knight and L. elisus Van D.; the rapid plant bug, Adelphocoris rapidus (Say); the superb plant bug, A. superbus (Uhler); Creontiades debilis (Van D.); C. fermoralis (Van D.); Neurocolpus nubilis (Say); and the ragweed plant bug, Chlamydatus associatus (Uhl.) are a complex of related plant bugs which cause damage to squares and small bolls of cotton. This group is a major problem, particularly in the irrigated regions of the West. DDT at the rate of 1 to 1 1/2 pounds per acre is the preferred insecticide for the control of these insects. The other organic insecticides recommended for boll weevil and bollworm control are also effective against these bugs.

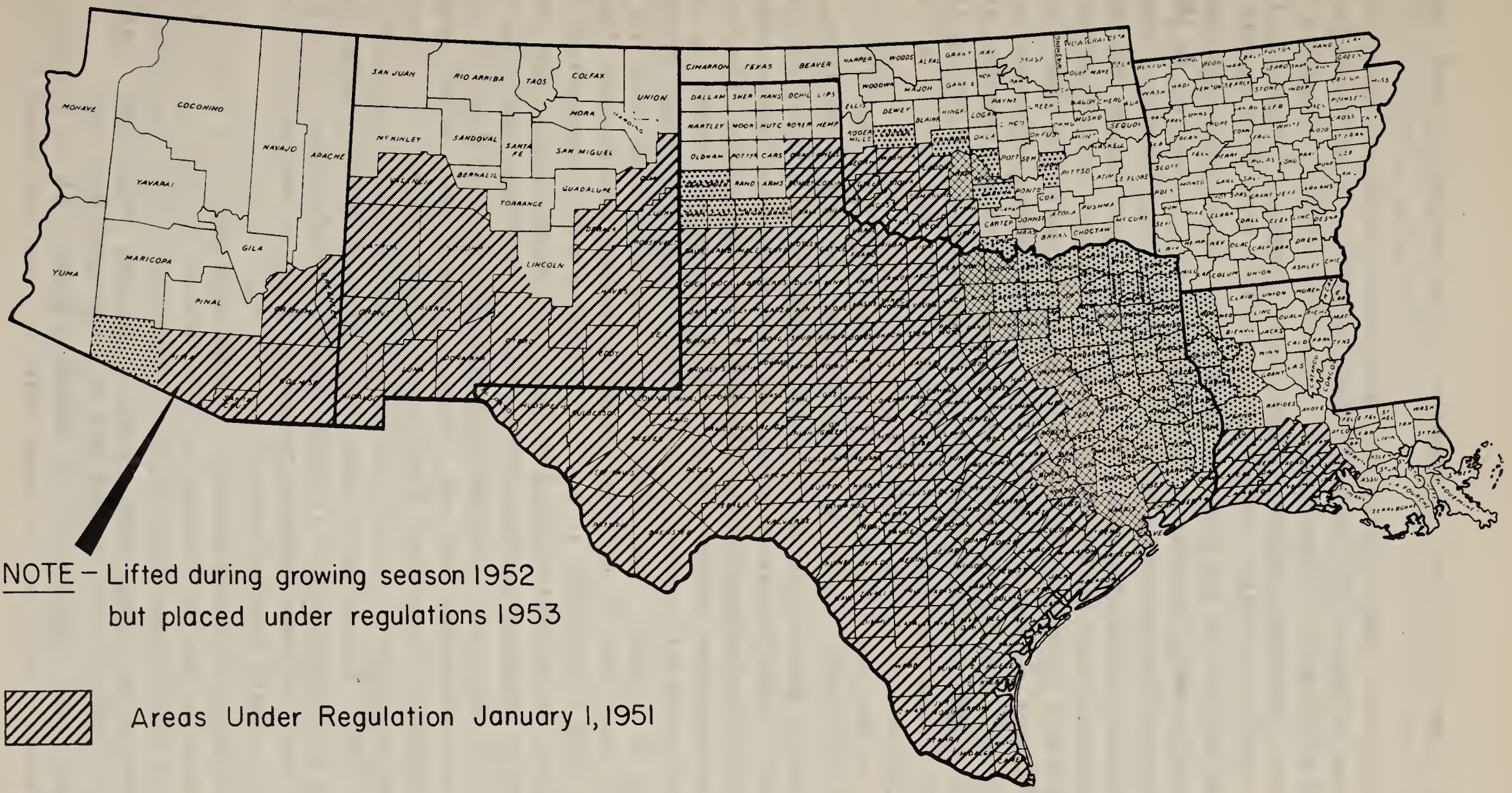
Pink Bollworm

Weather conditions favorable for survival of the pink bollworm, Pectinophora gossypiella (Saund.), coupled with failure to carry out known effective cultural practices, have resulted in an alarming increase in the infestation and a much wider spread of this insect during the last 3 years. Damaging infestations occurred throughout southern Texas during the 1952 season. In some of the fields over 90 percent of the crop was destroyed by the pink bollworm. The rapid spread and build up in the pink bollworm population emphasizes the need of developing control measures that can be readily carried out under all weather conditions.

To suppress the pink bollworm and to prevent its artificial spread all cottonseed should be sterilized by either heat treatment or methyl bromide fumigation. All lint should be compressed before it is moved into noninfested areas. Gin waste should be destroyed promptly by burning, or when used as a fertilizer, by composting or by heat treatment. Mechanical cotton pickers that have been operated in an infested area should be fumigated with methyl bromide before they are moved into a noninfested or lightly infested area. The cotton growers in such areas should examine the picking sacks and other personal effects of migrating cotton pickers and burn all seedcotton found.

There are a number of cultural practices that are helpful in reducing the pink bollworm infestation during the growing season. One of the first steps is to plant seeds that are free of infestation. Since there is a progressive build up in the pink bollworm population as the season advances, every effort should be made to expedite fruiting and setting the crop. The following practices are recommended for hastening the maturity of the cotton and thereby reducing the pink bollworm infestation: Early uniform planting of quick-maturing varieties; control of cutworms, thrips, cotton fleahoppers, boll weevils, and other insects that delay

PINK BOLLWORM REGULATED AREAS
JANUARY 1, 1953



NOTE – Lifted during growing season 1952
but placed under regulations 1953

Areas Under Regulation January 1, 1951

Areas Infested During Year Prior to January 1, 1952

Areas Placed Under Regulation During Year Prior to January 1, 1953

fruiting; clean cultivation; elimination of late irrigation; and chemical defoliation.

Crop losses from the pink bollworm can be reduced by the proper use of insecticides. DDT or a mixture of DDT with EPN are the most effective materials for its control. The DDT should be applied either as a dust or as a spray at the rate of 2 to 3 pounds of technical DDT per acre at weekly intervals. The mixture of DDT with EPN should be applied at the rate of 0.5 pound of EPN with 1.5 pounds of technical DDT per acre at weekly intervals. Where other insects as well as the pink bollworm require control, the DDT can be mixed with other insecticides. When the interval of application is reduced to 4 or 5 days for control of other insects, the quantity of DDT may be reduced accordingly or to the rate of 1.5 to 2 pounds per acre in combination with the other insecticides. DDT is compatible with other organic insecticides and with lime-free calcium arsenate. It may be mixed with regular calcium arsenate if used immediately afterwards, but the mixture should not be stored. Thorough coverage of the cotton plants with the insecticide is essential in the control of the pink bollworm.

Most of the pink bollworms are carried over from one crop year to the next in the bolls and locks of cotton that are left in the field. This overwintering population can be greatly reduced by proper cultural practices. In mild humid regions, such as southern Texas, the stalks should be cut immediately after the cotton is harvested. The best procedure is to cut the stalks with one of the new-type shredder cutters. These machines kill many of the pink bollworms during the process of shredding the stalks. They also shatter and spread the bolls on the surface of the soil, which permits a more thorough coverage of the debris when the land is plowed. In hot, dry weather a high percentage of the pink bollworms in the bolls and locks of cotton exposed on the ground are killed by the soil-surface temperature. Weather conditions permitting, plowing under the debris should therefore be delayed until about a week after the stalks are cut. During plowing every effort should be made to cover the debris as deeply as possible. Pink bollworm survival is six times higher in bolls buried only 2 inches deep than in bolls buried 6 inches deep. All sprout and seedling cotton developing after the plowing should be destroyed before fruiting so as to create a host-free period between crops. These cultural practices will not only control the pink bollworm but also the boll weevil.

In the lightly infested areas of central and eastern Texas, beyond the limits of regulated cultural controls where harvest is completed close to or after occurrence of frost, as many bolls as possible should be removed by snapping, mechanical stripping, or by heavy pasturing before the stalks are destroyed and the debris plowed under.

In cold, arid regions such as western Texas, where harvest must be completed after frost, as many bolls as possible should be removed

by snapping, mechanical stripping, or by heavy pasturing. The cotton stalks should be left standing during the winter months, since the highest mortality in such areas occurs in bolls on standing stalks. Where the stalks are plowed under early in the winter the fields should be winter irrigated. For best results the cultural practices outlined above should be carried out on a community-wide basis and the cooperation of every grower is needed.

Warning:--In areas where cottonseed are treated as a continuous process of ginning and gin trash is disposed of properly, records accumulated over a number of years prove beyond a doubt that pink bollworms are carried over from one year to the next principally in debris left on the soil in the fields. This is true even though the stalks may be cut promptly after harvest. Stop that carry-over by following, subjequent to stalk destruction, additional practices recommended for your area. In all infested areas start pink bollworm control measures before your crop begins to show actual damage from this dangerous insect.

Seed Corn Maggot

The seed corn maggot, Hylemya cilicrura (Rond.) may seriously affect the stand of cotton, particularly when planting closely follows the turning under of a green manure crop or other heavy growth. This insect may be controlled with 2 ounces of lindane applied as a wettable powder onto each 100 pounds of planting seed. Seed should be treated immediately before planting.

Spider Mites

Spider mites have become increasingly important pests of cotton. The use of organic insecticides for cotton insect control has been a major factor in the changing importance of these pests.

Species known to attack cotton in the United States are the two-spotted spider mite, Tetranychus bimaculatus Harvey; the Atlantic spider mite, T. atlanticus McG.; the Pacific mite, T. pacificus McG.; the desert spider mite, T. desertorum Banks; the tumid spider mite, T. tumidus Banks; the Schoene spider mite, T. schoenei McG.; the Canadian spider mite, T. canadensis (McG.); and the brown wheat mite Petrobia latens (Mueller). These species differ in their effect on the cotton plant and in their reaction to miticides. Accurate identification of the species is essential.

The two-spotted spider mite is the most difficult species of spider mite on cotton to control. It occurs as the green form in many areas and as the carmine subspecies (T. b. multisetis) in the South and in southern California. The green form can be controlled by applications

of Systox at 0.25 to 0.50, Aramite at 1, and Ovotran at 2 to 3 pounds per acre. Sulfur, TEPP, parathion, malathon, and EPN do not give effective control of the green form. Parathion at 0.10 to 0.40, Aramite at 1, Ovotran at 2 to 3 , and Systox at 0.25 to 0.40 pounds per acre give effective control of the carmine form.

The Pacific spider mite is restricted to the Pacific Coast, where it has been a major pest of cotton. Sulfur at 60, Systox at 0.25 to 0.40, Ovotran at 2 to 3, and Aramite at 1 pound per acre give effective control of this species. The organic phosphates are not satisfactory.

The Atlantic spider mite feeds in restricted colonies and causes strawberry-colored spots on the upper surface of the leaves. The bottom of the plant is attacked first and comparatively few mites can cause severe defoliation. Sulfur at 10 to 15, parathion at 0.3, Systox at 0.25 to 0.40, Ovotran at 2 to 3, and Aramite at 1 pound per acre give effective control.

The desert spider mite and the tumid spider mite are controlled by applications of sulfur at 20 to 25, parathion at 0.1 to 0.25, and Aramite at 0.3 to 0.75 pound per acre. TEPP at the rate of 0.5 pint of the 40-percent concentrate, or its equivalent, gives control of these species but several applications may be required.

The brown wheat mite may attack seedling cotton. Sulfur at the rate of 50 pounds per acre during warm weather and parathion at the rate of 0.3 pound per acre during cool weather control this species.

In some areas where mites are a problem, they may be effectively controlled by including comparatively low rates of miticides in all applications of cotton insecticides. For control of some species and as a depressant for others, at least 40-percent sulfur may be incorporated in all dust applications. Elemental sulfur can not be incorporated in sprays applied at low gallonage. Other miticides may be substituted.

Sulfur is most effective when finely ground and when applied at temperatures above 90° F. Thorough coverage is essential for effective results in the use of miticides.

Stink Bugs

Several species of stink bugs including the conchuela, Chlorochroa ligata (Say); the Say stink bug, C. sayi Stal; the southern green stink bug, Nezara viridula (L.); the green stink bug, Acrosternum hilare (Say); the brown cotton bug, Euschistus impictiventris Stal; the brown stink bug, E. servus (Say); E. variolarius (P. de B.); E. tristigmus (Say; the red-shouldered plant bug, Thyanta custator (Fab.); T. rugulosa (Say); T. brevis Van D.; and T. punctiventris Van D. attack cotton. The importance of these pests and the species involved varies from year to year and from area to area. The damage which they cause is usually confined to the more mature bolls and may result in reduced yields and

quality of both lint and seed. Dieldrin and BHC at 0.5 pound per acre have given excellent control of these stink bugs. Toxaphene at 6 pounds per acre has given fair to good control and is sometimes preferred where there is a bee hazard involved.

A dust containing 2 percent of BHC, 5 percent of DDT, and 50 percent of sulfur applied at the rate of 15 to 30 pounds per acre also gives excellent control of the insect complex consisting of stink bugs, lygus bugs, bollworms, and the cotton aphid and is widely used for the control of these pests in the Western areas.

Thrips on Seedling Cotton

Thrips often cause injury to cotton seedlings, especially in areas where vegetables, legumes, and small grains are grown extensively. The tobacco thrips, Frankliniella fusca (Hinds), onion thrips, F. tritici (Fitch), F. runneri (Morg.), F. exigua Hood, and Sericothrips variabilis (Beach) have been reported as damaging cotton seedlings. In some areas it has been shown that cotton plants usually recover and controls are not recommended, unless the stand is threatened. In other areas, to the contrary, it has been shown that thrips damage is more severe than generally realized. Although thrips usually injure seedling cotton, damaging infestations sometimes occur on older cotton in certain areas.

The destruction of leaf tissue by thrips, and subsequent slow plant growth, make the seedlings more susceptible to injury by diseases. Injury by thrips alone, or the combined injury of thrips and disease, may reduce or even destroy stands of young plants. A heavy infestation often retards plant growth and delays fruiting and crop maturity. This delay in crop maturity may increase the cost of harvest and may lower the quality of seed and lint because of the greater damage by insects and deterioration associated with unfavorable weather conditions.

A number of insecticides properly applied give satisfactory control of thrips and are recommended when the situation warrants their use. Toxaphene at the rate of 0.75 to 3 pounds of the technical material per acre in either dusts or sprays gives effective control. A spray mixture consisting of 0.5 of toxaphene plus 0.25 pound of DDT per acre, or a dust or spray mixture of DDT and BHC applied at a rate of 0.05 pound of gamma isomer plus 0.25 pound of DDT per acre is also effective.

Heptachlor or aldrin applied to young seedlings as a spray or dust at the rate of 0.08 to 0.125 pound per acre gives good thrips control. Dieldrin applied at the rate of 0.05 to 0.25 pound per acre is very effective.

Other insecticides that give satisfactory control either as a spray or a dust are chlordane at 0.5 to 1 pound per acre, BHC 0.1 to 0.2 pound of gamma isomer, and DDT 0.25 to 1.5 pounds. DDT has not given satisfactory control at temperatures above 90° F. Sprays are

more effective than dusts for thrips control on seedling cotton. When applications are made by airplane, the dosages mentioned above should be increased by at least 50 percent.

Some of the phosphate compounds are effective against thrips, but are not generally recommended because they are extremely poisonous. See Bean Thrips on p. 29.

Tobacco Budworm

The tobacco budworm, Heliothis virescens (F.), represents an important part of what has been referred to as the "bollworm complex" in the States from Texas eastward. In this area during the early part of the fruiting period the budworm is usually more abundant on cotton than the true bollworm. As the season progresses the relative abundance of these two species gradually changes. By the time cotton matures, abundance of the two species is roughly the same in the Carolinas, while in Texas the budworm has reverted to a position of minor importance.

So far as is known, controls that are effective against the bollworm on cotton are equally effective against the tobacco budworm.

White-fringed Beetle

The white-fringed beetle, Graphognathus leucoloma (Boh.), and G. peregrinus (Buch.), and G. minor (Buch.) are pests of cotton and many other farm crops. They are present in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee.

Larvae of the white-fringed beetles damage cotton by feeding on the roots of young plants. These insects can be controlled by the use of good cultural practices and insecticides. Good cultural practices recommended include the following:

1. Plant oats or other small grains in heavily infested areas.
2. Restrict planting of summer legumes, such as peanuts, soybeans, velvetbeans, or other faborable host plants of the adult beetles to not more than one-fourth of the total crop land. Do not plant these crops on the same land more often than once in 3 or 4 years.
3. Do not intercrop corn with peanuts, soybeans, crotalaria, or velvet beans. Prevent the growth of broadleaved weeds, such as cocklebur and sicklepod.
4. Improve poorer soils by turning under winter cover crops.

DDT is effective for control of white-fringed beetle larvae. Apply 50-percent DDT at the rate of 20 pounds per acre, or 25-percent DDT

at the rate of 40 pounds per acre, evenly to the soil surface as a dust, spray, or mixed with sand. Thoroughly mix it into the upper 3 to 4 inches of soil. This treatment will give control of larvae for at least 5 years. DDT may be used in the drill before planting. Use 50-percent DDT at the rate of 5 to 10 pounds per acre, or 25-percent DDT at the rate of 10 to 20 pounds per acre, mixed with sand. This mixture may be applied by hand or by a fertilizer distributor, at or slightly below the depth of seed planting.

Either toxaphene or BHC-DDT mixture applied on cotton foliage gives a residue in the soil that aids in the control of these beetles. These insecticides should be used for the control of those cotton insects for which they are recommended in white-fringed beetle infested areas.

White-lined sphinx

The white-lined sphinx, Celerio lineata (F.), occasionally occur in uncultivated areas in large numbers and migrate to cottonfields. In the cottonfields they may be controlled with DDT at 1 to 1.5 or with toxaphene at 2 to 3 pounds per acre applied as dusts or sprays. Migrations may be stopped by barrier strips of 10 percent of DDT or 20 percent of toxaphene.

Whiteflies

Whiteflies are usually kept in check by parasites but occasionally may be serious late in the season. Parathion at 0.25 to 0.5 pound per acre is effective in controlling these insects, but is also very detrimental to their parasites. DDT, TDE, and methoxychlor are also effective against whiteflies.

Wireworms

Several species of wireworms are associated with cotton. Perhaps most noticeable damage is caused by the sand wireworm, Horistonotus uhlerii Horn., in South Carolina, Louisiana, and Arkansas. Adults of the tobacco wireworm (spotted click beetle), Conoderus vespertinus (F.), are frequently found on the cotton plant, but the amount of damage to cotton caused by larvae of this species is not known. Wireworms in combination with false wireworms and the seed corn maggot sometimes prevent the establishment of a stand of cotton. This may be prevented by treating the seed with 2 ounces of lindane per 100 pounds in a slurry.

Approved crop rotation practices, increased soil fertility, and added humus help to reduce damage to cotton caused by the sand wireworm. Aldrin, DDT, and BHC have shown promise in the control of this and other species of wireworms on other crops. Additional research on

the control of wireworms attacking cotton is needed. Chlordane at the rate of 1 pound per acre as a row application is effective.

Yellow-Striped Armyworms

The yellow-striped armyworm, Prodenia ornithogalli Guen., and the western yellow-striped armyworm, P. praefica Grote, may at times cause considerable damage of cotton. Prodenia ornithogalli has proved to be the most difficult of all the "bollworms" to kill with organic insecticides. EPN (O-ethyl O-p-nitrophenyl benzenethiophosphonate) at 0.3 pound per acre applied as an emulsion spray was superior to any of the chlorinated hydrocarbons. However, when used in the early stages of worm development, toxaphene at 2.5 pounds per acre, DDT at 1 pound, and dieldrin at 0.3 pound in an emulsion spray gave fair control. Dieldrin in a 3-percent dust and toxaphene in a 20-percent dust applied at the rate of 15 pounds per acre also gave good kills of a mixed population of large and small yellow-striped armyworms.

The western yellow-striped armyworm, which only attacks cotton in California, is easily controlled with DDT at the rate of 1 to 1.5 pounds per acre when these insects are in the cotton. Migrations from surrounding crops may be stopped by barriers of 10-percent DDT or 20-percent toxaphene at the rate of 2 to 4 pounds per 100 feet.

Miscellaneous Insects

The cabbage looper, Trichoplusia ni (Hbn.), and several other closely related species occasionally cause damage to cotton in localized areas. Dusts containing 10 percent of DDT or 20 percent of toxaphene, or a combination dust containing 5 percent of DDT and 15 percent of toxaphene applied at the rate of 10 pounds per acre or sprays containing toxaphene or DDT applied at the respective rates of 2 pounds and 1 pound per acre are effective.

The corn silk beetle, Luperodes brunneus (Crotch), has been reported as a pest of cotton in localized areas in several States but little is known about it.

Cotton root aphids: The species of root aphids known to attack cotton are the corn root aphid, Anuraphis maidi-radicis (Forbes); Triphidaphis phaseoli (Pass.); and Rhopalosiphum subterraneum Mason. So far as is known, injury by root aphids to cotton is confined to the eastern Seaboard. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant, Lasius niger alienus americanus Emery. Chemical control of root aphids has been directed at control of the cornfield ant. Some of the newer materials are known to be effective as soil insecticides, and it is suggested that they be tested against root aphids attacking cotton. They injure cotton chiefly in the seedling stage.

Since cotton in this stage often shows signs of injury without any evidence of insects being present, it is suggested that careful examinations of the underground portions be made to determine the possibility of root aphid attack. Ant mounds at the base of seedling plants indicate the presence of root aphids.

The cotton square borer, Strymon melinus (Hbn.), occurs throughout the Cotton Belt, but rarely causes economic damage. The injury this insect causes to squares is often attributed to the bollworm.

The cotton stainer, Dysdercus suturellus (H.-S.), is found within the United States in Florida only. However, probably owing to mistaken identity, the literature also records it from Alabama, Georgia, and South Carolina. No work on control has been formally reported in recent years, but observations indicate that dusts containing 10 percent of toxaphene or sufficient BHC to give 1 percent of the gamma isomer will control insects of this genus. Indications are that DDT may also be effective in some areas.

The cowpea aphid, Aphis medicaginis Koch, occurs commonly on very young cotton, especially on the cotyledonous leaves. Cotton is not believed to be a true host of this species, and the insect will not complete a life cycle on the cotton seedling.

Flea beetles: These insects damage young cotton in some areas. They can be controlled with chlordane at the rate of 0.5 pound per acre as a dust or spray, with aldrin at the rate of 0.25 to 0.5 pound per acre, with dieldrin at the rate of 0.25 to 0.33 pound per acre, with DDT at the rate of 1 pound per acre, or with toxaphene at the rate of 2 to 3 pounds per acre.

The salt-marsh caterpillar, Estigmene acrea (Drury), can be controlled with toxaphene applied as either a dust or a spray at the rate of 3 pounds of technical material per acre, preferably when worms are small. If worms are large, 4 to 5 pounds of toxaphene in a spray or a dust containing 5 percent of DDT plus 15 percent of toxaphene plus 40 percent of sulfur applied at the rate of 20 to 40 pounds per acre will be required.

Insects That Attack Cottonseed in Storage

Cottonseed rarely becomes infested with insects while in storage when proper precautions are followed. Cottonseed or seed cotton should be stored only in a bin or room thoroughly cleaned of all old cottonseed, grain, hay, or other similar products in which insects that attack stored products are likely to develop. Among the insects that cause damage to stored cottonseed or to cottonseed meal are the cigarette beetle, Lasioderma serricorne (F.), the Mediterranean flour moth, Ephestia kuhniella Zell., and the Indian-meal moth, Plodia interpunctella (Hbn.). Cottonseed that is to be used for planting only may be dusted with toxaphene before being placed in storage. Seed so treated should not be crushed or used for feed.

Biological Control of Cotton Insects

Predators, parasites, and diseases play an important role in the control of insect pests of cotton. Full advantage should be taken of these natural enemies and the over-all pest control program should include the maximum integration between natural and artifical control. To reach this goal there is an urgent need for fundamental studies on the ecology of cotton insects and their enemies and the effect of chemical control upon their relationships. An integrated pest-control program is most likely to reach its greatest efficiency with the expansion of programs such as supervised control. Wherever possible, an attempt should be made to evaluate the role of beneficial insects in the fields being checked.

To date the importation and colonization of insect parasites of the pink bollworm and boll weevil have not proved especially effective. On the other hand, native predators and parasites are important to a greater or less degree on such pests as the bollworm, spider mites, lygus bugs, whiteflies, and the cotton aphid.

Control of Cotton Insects in the Irrigated Southwest

Cotton insect problems in the irrigated Southwest are somewhat different from those in the remainder of the Cotton Belt because of differences in climate, cultural practices, and kinds of insects present.

The combination of alkalinity, intense sunlight, high temperatures (regularly over 100° F. and frequently exceeding 110° F.), low humidity, and in most areas an absence of precipitation during the growing season make the environment of the cotton plant and its pests quite different from that in the South. Furthermore, this environment is complicated by intermittent irrigations which bring severe changes to the environment. The large size of most Western ranches and fields complicates insect control in some ways and simplifies it in others. Also such cultural practices as double cropping, extensive use of commercial fertilizers, mechanical picking and one-variety districts modify insect problems in the Southwest.

These factors in conjunction with local and general isolation give the Southwest a different insect complex. The boll weevil, the pink bollworm, and the cotton leafworm are absent or are only local problems. The most important pests are lygus bugs, the bollworm, three species of spider mites, and several stink bugs. Early season pests are wireworms, the seed corn maggot, darkling ground beetles, cutworms, the beet armyworm, the white-lined sphinx, thrips, and spider mites. Thrips, although very abundant, do not seem to cause serious damage unless the stand is threatened. In midseason the three species of lygus bugs and other mirids are easily controlled with DDT. The bollworm

has been increasing in importance over the last 5 years, but very satisfactory control can be obtained with DDT if treatments are properly timed. Certain systemics show great promise on spider mites but further research is needed. A number of minor pests attack cotton in the irrigated areas during midseason and late season. They include the salt-marsh caterpillar, the bean thrips, the western yellow-striped armyworm, the cotton aphid, the cotton leaf perforator, whiteflies, and the cabbage looper.

In general, in the Southwest insecticides are applied less frequently but in larger amounts than in other parts of the Cotton Belt, i.e., the pounds are higher (15 to 35 pounds per acre) and the actual toxicant per acre slightly higher. Nearly all treatments except early applications are applied by aircraft. Predators and parasites seem to be particularly important on pests of cotton in the Southwest, and every effort is made to protect them and to utilize them to the fullest.

Supervised control has been increasing in its importance especially in California. This is a system of entomological field supervision in which the fields are scouted on at least weekly intervals by unbiased and specially trained personnel. Every effort is made to take advantage of beneficial insects, to apply the latest control information to the particular situation in the individual field, and to give the farmer a recommendation especially tailored to his conditions.

The combination of a simpler insect problem, favorable growing conditions, controlled soil moisture, and intensified agriculture produces the greatest yields of cotton in the world.

Cotton Insect Surveys

The importance of surveys to an over-all cotton insect control program has been clearly demonstrated during the last few years. Cotton insect surveys conducted on a cooperative basis by State and Federal agencies in most of the major cotton-growing States have developed into a broad, currently advisory service for the guidance of the farmer, others associated with cotton production, and the industry that serves the farmers by supplying insecticidal chemicals. As a result of survey work, farmers are forewarned of the insect situation and losses are materially reduced below what they would be without the information thus gained. The survey also helps to direct insecticides to areas where supplies are critically needed.

More people are being employed each year by business firms, individual farm operators, and others interested in cotton production to determine cotton insect populations. It is important that individuals employed by private interests to make surveys understand the control programs as well as how to make infestation counts. Therefore, State and Federal entomologists should assist in locating and training

personnel that have at least some basic work in entomology to survey for private interests. If this is not done, many growers are sure to be misinformed about recommended control practices. Therefore, it is recommended that cotton insect surveys be continued on a permanent basis, that they be expanded to include all cotton-producing States, and that the survey methods be standardized to produce duplicatable and comparable data.

It is further recommended that the greatest possible use be made of fall, winter, and early spring survey methods to aid in our presentation of the next season's potential insect infestation.

Wherever possible, it is well to enlist and train voluntary cooperators to make field observations and records and to submit reports during the active season.

Supervised Control

Supervised control, a system of entomological field supervision, has been increasing in importance in many cotton States. Fields are scouted at least weekly by unbiased and specially trained personnel, and control measures are recommended only when necessary. Supervised control makes chemical treatments more effective by improving the timing of applications and eliminating needless treatments. Furthermore, full advantage is taken of any biological or cultural controls available. Many farmers have used insecticides carelessly and unnecessarily because information on destructive insects has been inadequate. This expense has been unwarranted and, furthermore, the treatments have been harmful to beneficial insects. Since all potentially destructive populations are located before they have had a chance to do any damage, timing of control measures is as near perfect as practically feasible.

Every recommendation is tailor-made for each individual field and all the factors involved are considered in relation to the situation before any recommendations are made.

Extension Educational Program for 1953

There is a serious need for a strong educational program that will present the facts concerning cotton insect control. This program should be conducted in such a way that everyone interested in cotton production will be reached. Growers especially need these facts to help them in making plans for 1953.

In order that cotton growers may follow the recommendations made by the State and Federal entomologists without confusion, such recommendations must be basically the same in areas where the insect problems are similar. Points upon which agreement must be reached

are (1) insecticides that are effective, economical, and safe to use with proper precautions, (2) time to start treatment, (3) rate of application, (4) interval between applications, and (5) how to apply the insecticides. Confusion will seriously interfere with effective insect control if these points are not agreed upon.

To facilitate the production of the required 1953 crop of cotton, the Extension Service will immediately strengthen and intensify its educational work on the seven-step cotton-production program. To help accomplish the goal each State should have the following committees: (1) A State-wide cotton production committee made up of representatives from all agencies and organized groups within the State to help develop, promote, and provide leadership to the program; (2) a technical committee made up of representatives from all State and Federal agricultural agencies to prepare recommendations on cotton production and insect control; (3) an extension committee selected by the State Director, which will be responsible for the educational program. Each county or parish should be organized on a basis somewhat comparable to that of the State.

Experience has shown that committees such as those previously outlined play an important part in the planning and carrying out of an integrated program in which all agencies and segments of industry can cooperate. As a result of the cooperative effort, growers will be kept informed of the need for insect control and industry will know better the need for insecticides.

The extension program will stress teaching cotton growers to examine their cotton fields at least once each week to determine the degree of insect infestation. They will also teach farmers to evaluate their findings in order to apply insecticides effectively and economically.

The following steps, listed on a seasonal basis, outline the extension program that will be carried out in varying degrees in the Cotton States:

Winter

A. State or area meetings with insecticide suppliers and applicators.
B. District meetings with county agents and farm leaders.
C. Through general county meetings, press and radio releases, circular letters and posters stress the cotton insect control program. Also encourage growers to arrange for purchase of insecticides and to get equipment in shape for next season.
D. Securing the cooperation of farm loan agencies, oil mills, ginners, fertilizer associations, and other groups concerned with the production of cotton.

Spring

A. Release information from surveys by State and Federal entomologists on boll weevil survival.
B. Continuation of meetings on cotton insect control.
C. Demonstrations on procedure for making cotton insect counts per acre in order to determine when and where early boll weevil control is needed.
D. Issue recommendations on early season cotton insect control.
E. Conduct 4-H Club meetings devoted to cotton insects and their control.

Summer

A. Release survey information on insect infestation.
B. Field demonstrations on insect identification, infestation counts, and proper application of insecticides.
C. Timely radio programs, newspaper articles, and circular letters on insect conditions and control.
D. Field tours to study demonstrations and experiments on cotton insect control.
E. Daily radio reports on weather conditions.

Fall

A. Stressing of importance of defoliation in preventing insect damage to young bolls.
B. Promoting an early stalk destruction program to reduce insect populations.

Educational Tools

Full use should be made of the following educational tools to stimulate the adoption of recommended practices:

1. Publications--yearly recommendations.
   a. Plan of organizational set-up showing responsibility of each agency.
   b. Yearly recommendations for insect and disease control.
2. Mimeographed informational material.
3. Posters, charts, exhibits at fairs, models.
4. Magazine articles.
5. Cotton letter or other circular letters.
6. Newspaper publicity, special editions.

7. Radio spot announcements and recordings. Sponsored program at set time and day each week so as to build up a listening audience for the program.
8. Public meetings.
9. Individual contacts.
10. Slides and motion pictures.
11. Television where available.
12. Equipment displays at method demonstrations.
13. Result demonstrations.
14. Visits to Experiment Stations.

Cotton Insect Conditions in Puerto Rico

Although Puerto Rico was not represented at the Conference, Dr. Luis F. Martorell, Entomologist, Agricultural Experiment Station, University of Puerto Rico, Rio Piedras, P. R., submitted by airmail 100 copies of a brief report on cotton insect conditions for the years 1951 and 1952 for distribution at the Conference. The most important pests of cultivated Sea Island cotton during the last 2 years were the pink bollworm, the cotton aphid, and the cotton leafworm. The pink bollworm is controlled by DDT and the cotton aphid by BHC. The cotton leafworm has appeared each year since the spring of 1949, although it was not observed in Puerto Rico during the 7 previous years. The bollworm did not cause noticeable injury to cotton during the last 2 years, and the boll weevil has never been reported from Puerto Rico.

Needed Research

Additional information is needed on the life history, habits, biology, ecology, host plants, natural enemies, and control of each of the insects and mites injurious to cotton that are mentioned in this report, especially in areas and under conditions where extensive studies have not been conducted.

Under present conditions in the United States every effort should be made to expand and improve the research relating to the pink bollworm, the bollworm, the tobacco budworm, the boll weevil, spider mites, thrips, and cutworms injurious to cotton. Every phase of natural control, cultural control, and control by means of mechanical equipment and chemicals should receive attention. Special phases of cotton insect research suggested by this conference are grouped under the seven headings given below. Each of these groups is interrelated with problems covered by other groups and progress in one problem often contributes to progress in others. Under each heading is listed lines of research in which additional information is especially needed.

I. Insecticides and miticides.
   A. Improved materials and equipment for controlling cotton pests.
      1. Evaluation of new toxicants and mixtures of toxicants, solvents, emulsifiers, and dust diluents under the varying conditions of cotton production.
      2. Design of machinery and equipment for applying sprays and dusts, including aircraft particularly adapted to various agricultural needs.
      3. Relation of temperature, humidity, sunlight, rainfall, and air currents to the effectiveness of insecticides.
      4. Relation of coverage, particle size, distribution, adherence, and residual toxicity of insecticides to cotton insect control.
      5. Factors influencing the deterioration of insecticides in storage.
      6. Improved techniques for testing insecticides.
      7. Systemic insecticides.
   B. Improved timing of treatments.
      1. With respect to development and fruiting of the cotton plant.
      2. Of early season infestations and their relation to the subsequent development and yield of cotton.
      3. The value of community action in controlling cotton insects.
      4. In relation to seasonal development, life histories, and habits of the major cotton pests and others that are potentially injurious.
   C. Effects of pesticides on plants, soils, and animals.
      1. Upon the physiological and phytotoxic reaction of cotton plants.
      2. Upon soils and subsequent crops when applied to cotton.
      3. Upon natural enemies of cotton insects.
      4. Upon livestock, poultry, wild life, and man.
      5. Upon honey bees and other pollinating insects.
      6. Upon the possibility of contamination with organic insecticides of food and feed from cotton and by drift to other crops when applied for the control of cotton insects.

II. Improved methods of forecasting damage by cotton insects and mites.
   A. Through improved methods of determining infestations.
   B. Through studies of ecological factors, cropping systems, natural enemies, cultural practices, plant nutrition, and migration.

III. Combining insect control with other operations in mechanized production of cotton. Use of shredders and larger and better plows.

IV. Defoliation in relation to the control of cotton insects.

V. Parasites, predators, and diseases of cotton insects and mites and possible carriers of diseases of cotton plants.
VI. Physiological, biochemical, and nutritional studies on cotton insects.
   A. The physiological mode of action of pesticides on insects and mites.
   B. The effect of sublethal dosages of insecticides upon insect reproduction and development.
   C. The possibility of the development of insect resistance to insecticides.
VII. Coordination of observations and studies of cotton insect activities and distribution on an international basis--for example the migration of the cotton leafworm.

Conferees at Third Memphis, Tenn., Conference, December 7, 8, and 9, 1952

Eighty-one entomologists and associated technical workers concerned with cotton insect research and control participated in the Cotton Insect Research and Control Conference held at Memphis, Tenn., December 7, 8, and 9, 1952. They were from the Agricultural Experiment Stations, Extension Services, and other agencies in 13 cotton-growing States, the United States Department of Agriculture, and the National Cotton Council of America. The statements in this report were agreed upon and adopted by all the following conferees:

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(Only seven States in continental United States where cotton is grown commercially were not represented at this conference--Florida, Kansas, Kentucky, Missouri, Nevada, New Mexico, and Virginia. Florida, Missouri, Virginia, and Puerto Rico have sent entomologists to some of the previous conferences).

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